Dynamic Emissivity Estimates to Support Physical Precipitation Retrievals for GPM

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1. Background

- Land surface emissivity is of critical importance for the microwave based precipitation retrieval algorithm development.
- Land surface emissivity is highly heterogeneous and dynamic, makes it difficult to estimate using physical model
- We have developed a statistical framework to estimate land surface emissivity directly from brightness temperature (TBs)
- This method is successfully applied to Southern Great Plains (SGP) by Tian et. al. (2015), which outperforms the physical model and hybrid of physical and statistical model
- We now extend this frame work to the GPM-covered region (65S-65N)

3. Datasets

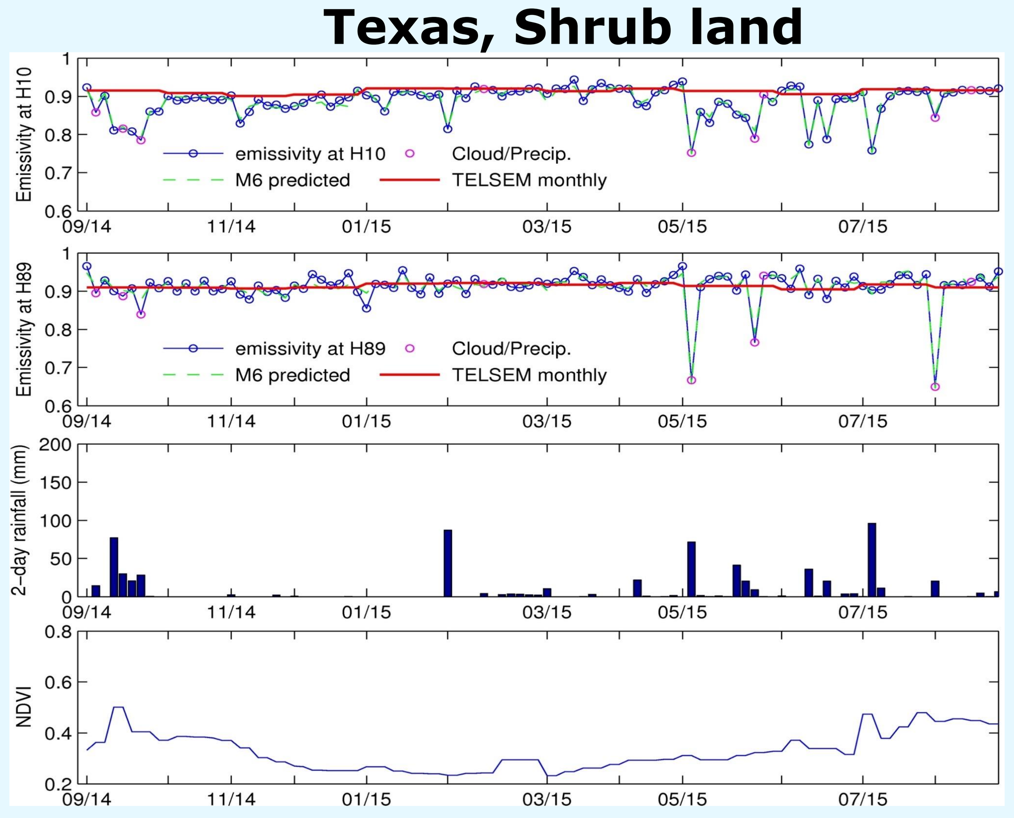
- Emissivity retrieved from GMI observed Tbs via radiative transfer model (Joe Munchack).
- GMI TBs (V10, H10, V19, …, V166, and H166)
- IMERG 30-minute precipitation data
- TELSEM climatology (Monthly) emissivity
- MODIS Normalized Difference Vegetation Index (NDVI) (8-day and 250-meter)
- Temporal coverage: 09/2014 to 08/2015
- Spatial coverage: 65S-65N

2. Methodology

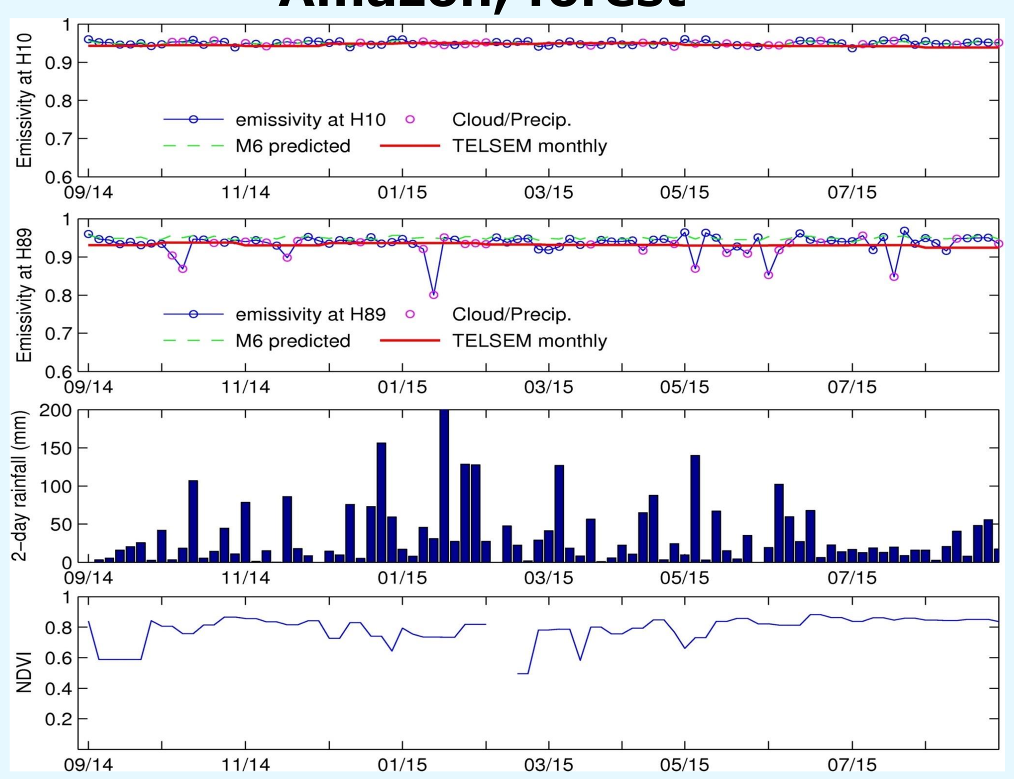
- Emissivity from 10 to 166 GHz is regressed directly from TB-based predictors
- Predictors include: TB, TB^2, and Microwave Polarization Difference Index (MPDI, e.g., (V10-H10)/(V10+H10))
- We have tested six different regression models
  - Method 1 (M1): single channel MPDI (10 GHz) and its square (2-predictor)
  - Method 2 (M2): 4-channel MPDI (10, 19, 37, and 89G), linear terms only (4-predictor)
  - Method 3 (M3): 9-channel TBs: 10~89 GHz, linear terms only (9-predictor)
  - Method 4 (M4): 9-channel TB and 4-channel MPDI, linear terms only (13-predictor)
  - Method 5 (M5): 9-channel TB, 9-channel TB2, and 4-channel MPDI (22-predictor)
  - Method 6 (M6): 11-channel TB, 11-channel TB2, and 5-channel MPDI (27-predictor)
- Data are randomly divided into two sub-sets. one for training and the other one for validation.·

4. Cases over different regions

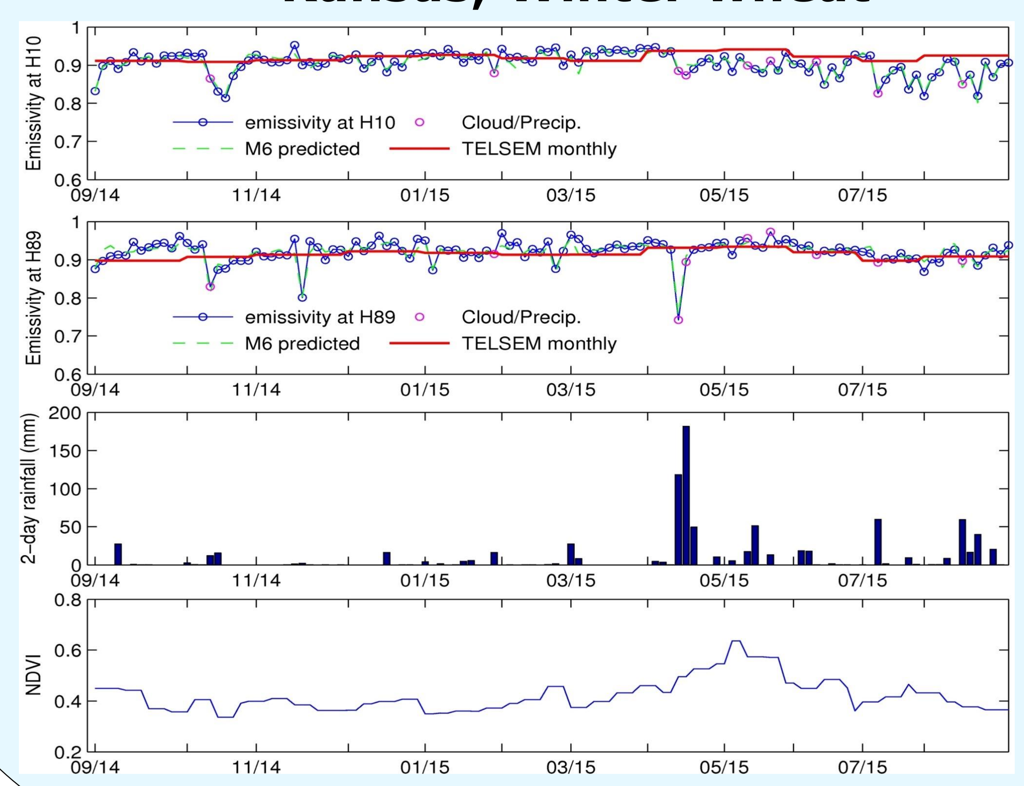
Texas, Shrub land



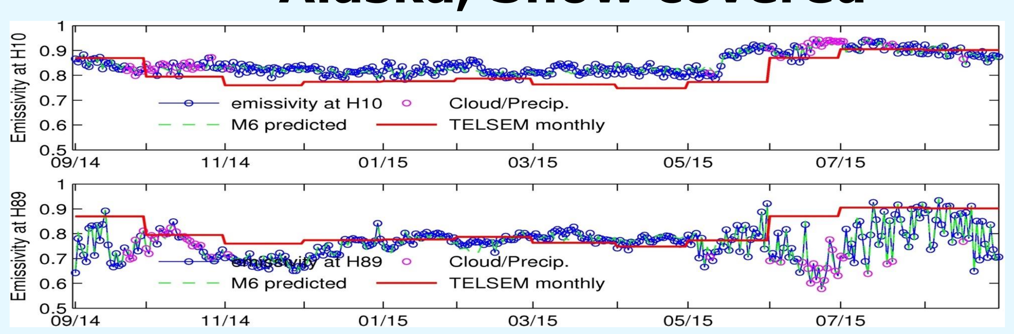
Amazon, forest



Kansas, Winter wheat



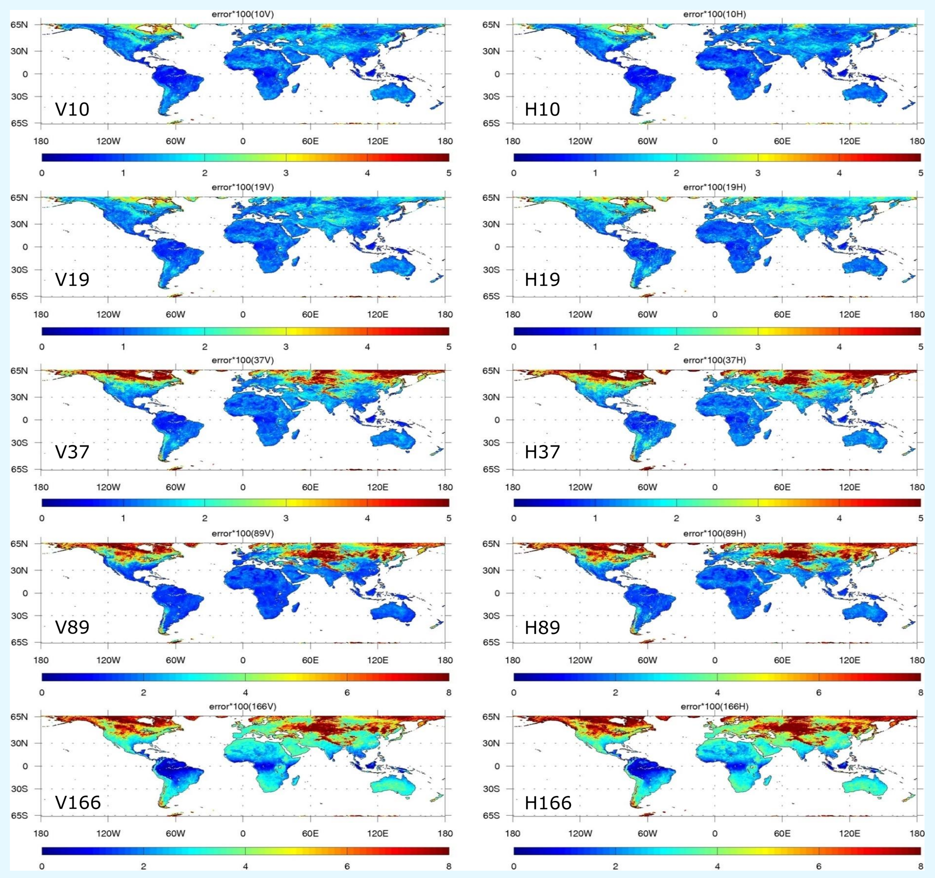
Alaska, Snow covered



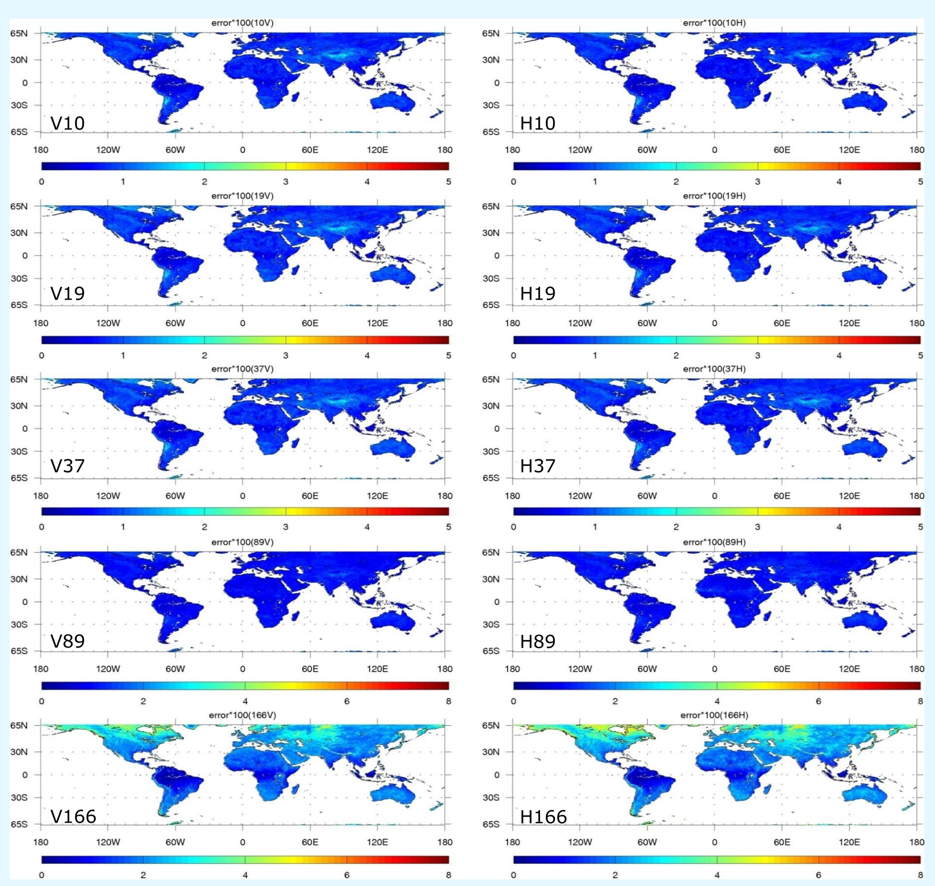
- Many factors can lead to a large emissivity variation, including precipitation, irrigation, snow melting
- Under all conditions, our method performs very well; able to capture the dynamical change of the emissivity
- Over the Amazon forest region, a constant emissivity estimate is sufficient

5. Emissivity error estimates

Error estimates (M1)



Error estimates (M6)



Error table

	M1	M2	M3	M4	M5	M6
V10	1.36	1.30	0.90	0.87	0.99	0.97
H10	1.26	1.21	0.84	0.82	0.91	0.92
V19	1.40	1.32	0.96	0.93	1.05	1.03
H19	1.53	1.24	0.90	0.86	0.96	0.89
V24	1.56	1.42	0.97	0.94	1.05	1.03
V37	2.18	1.88	0.98	0.86	1.07	1.02
H37	2.46	1.81	0.94	0.91	1.02	1.01
V89	3.42	2.83	1.20	1.16	1.33	1.26
H89	3.73	2.79	1.26	1.23	1.39	1.31
V166	4.29	3.82	2.82	2.79	3.25	2.48
H166	4.65	4.11	3.12	3.10	3.65	2.80

- In general, more predictors produce lower errors. Over-fitting may be an issue due to the sample size
- Emissivity estimated by 10GHz TB for all channels from 10 to 166 GHz is very accurate over the forest region (e.g., Amazon)
- High-latitude (cold surface) is less accurate

Conclusions:

- A real-time land surface emissivity estimation method is extended to the GPM-covered region
- This method captures the dynamic and heterogeneous emissivity characteristics over various regions, with average error of 0.97% to 2.80%
- The parameters in this method are directly derived from TBs without any ad hoc tuning, making it ideal for real-time application
- Future work seeks to: (1) use a better cloud/precipitation screening method; (2) obtain more data for training and validation; (3) investigate the estimation over different seasons; (4) test the dynamic emissivity in the GPM radiometer retrieval algorithm

Reference: Tian, Y., C. D. Peters-Lidard, K. W. Harrison, Y. You, S. Ringerud, S. Kumar, and F. J. Turk (2015), An examination of methods for estimating land surface microwave emissivity, *J. Geophys. Res. Atmos.*, 120, 11,114–11,128.